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In re the application of:)
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Serial No.: 10/706,940   )   Art Unit: 2873
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Filed: November 14, 2003   )   Examiner: Evelyn A. Lester

For: TAKING LENS SYSTEM

Commissioner for Patents
U.S. Patent and Trademark Office
2011 South Clark Place
Customer Window, Mail Stop Petition
Crystal Plaza Two, Lobby, Room 1B03
Arlington, VA 22202

Sir:

<u>VERIFICATION OF A TRANSLATION</u>

I, Kanzo Komazawa, a translator working for SANO PATENT OFFICE, having my business office at Tenmabashi-Yachiyo Bldg. Bekkan, 2-6, Tenmabashi-Kyomachi, Chuo-Ku, Osaka-Shi, Osaka 540-0032, Japan, hereby declare and say:

That I am thoroughly conversant with both the Japanese and English languages; and that the attached document represents a true English translation of Japanese Patent Application No. 2002-331617 filed in the JPO on November 15, 2002, for which priority benefits are claimed under 35 U.S.C. §119.

I further declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so

made are punishable by fine or imprisonment, or both, under §1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Signed this 16th day of May, 2005.

Signature: _____*K. Komazawa*_____

Name: Kanzo KOMAZAWA

JAPAN PATENT OFFICE

This is to certify that the annexed is a true copy of the following application as filed with this Office.

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Application Number: Patent Application No. 2002-331617
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[Title of the Invention]   TAKING LENS SYSTEM

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[List of the Attached Documents]

[Title of the Document]	Specification	1 copy	
[Title of the Document]	Drawings	1 copy	
[Title of the Document]	Abstract	1 copy	
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[Proof]   Required

[Title of the Document]   Specification

[Title of the Invention]   TAKING LENS SYSTEM

[Claims]

5   [Claim 1]

A three-lens-element taking lens system for forming an image on a solid-state image sensor, comprising, from an object side, a first lens element having a positive optical power, an aperture stop, a second lens element having a positive optical power, and a third lens element having a negative optical power and having a concave surface pointing to an image

10   side,

wherein, of the first and second lens elements, one is a glass lens element and the other is a plastic lens element,

wherein the third lens element is a plastic lens element, and

wherein the following condition is fulfilled:

15    $$0.3 < f / fG < 2.6 \qquad (1)$$

where

f   represents a focal length of the taking lens system as a whole; and

fG   represents a focal length of the glass lens element having a positive optical power.

20   [Claim 2]

A three-lens-element taking lens system for forming an image on a solid-state image sensor, comprising, from an object side, a first lens element having a positive optical power, an aperture stop, a second lens element having a positive optical power, and a third lens element having a negative optical power and having a concave surface pointing to an image

25   side,

wherein, of the first and second lens elements, one is a glass lens element and the other is a plastic lens element,

wherein the third lens element is a plastic lens element, and

wherein the following condition is fulfilled:

30    $$0.05 < TG / fG < 1.35 \qquad (2)$$

where

TG   represents an axial thickness of the glass lens element having a positive optical power; and

1

fG   represents a focal length of the glass lens element having a positive optical power.

[Claim 3]

A three-lens-element taking lens system for forming an image on a solid-state image sensor, comprising, from an object side, a first lens element having a positive optical power, an aperture stop, a second lens element having a positive optical power, and a third lens element having a negative optical power and having a concave surface pointing to an image side,

wherein, of the first and second lens elements, one is a glass lens element and the other is a plastic lens element,

wherein the third lens element is a plastic lens element, and

wherein the following condition is fulfilled:

$$| f3 | / fP < 2.6 \tag{3}$$

where

f3   represents a focal length of the third lens element; and

fP   represents a focal length of the plastic lens element having a positive optical power.

[Claim 4]

A three-lens-element taking lens system for forming an image on a solid-state image sensor, comprising, from an object side, a first lens element having a positive optical power, an aperture stop, a second lens element having a positive optical power, and a third lens element having a negative optical power and having a concave surface pointing to an image side,

wherein, of the first and second lens elements, one is a glass lens element and the other is a plastic lens element,

wherein the third lens element is a plastic lens element, and

wherein the following condition is fulfilled:

$$0.05 < T3 / f < 0.5 \tag{4}$$

where

T3   represents an axial thickness of the third lens element; and

f   represents a focal length of the taking lens system as a whole.

[Claim 5]

A three-lens-element taking lens system for forming an image on a solid-state image

sensor, comprising, from an object side, a first lens element having a positive optical power, an aperture stop, a second lens element having a positive optical power, and a third lens element having a negative optical power and having a concave surface pointing to an image side,

wherein, of the first and second lens elements, one is a glass lens element and the other is a plastic lens element,

wherein the third lens element is a plastic lens element, and

wherein the following condition is fulfilled:

$$VG > 58 \tag{5}$$

where

VG   represents an Abbe number of the glass lens element having a positive optical power.

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a taking lens system, and more particularly to a compact taking lens system suitable for use in a digital input apparatus (such as a digital still camera or digital video camera) that takes in an image of a subject by means of a solid-state image sensor.

[0002]

[Prior Art]

In recent years, as personal computers and the like become more and more popular, digital still cameras and digital video cameras (hereinafter collectively referred to as "digital cameras"), which permit easy entry of image data into digital equipment, have been becoming more and more popular for personal use among general users. Such digital cameras are expected to become even more widespread as image data input devices in the future.

[0003]

Solid-state image sensors, such as CCDs (charge-coupled devices), used in digital cameras have been made increasingly small, and accordingly further miniaturization is sought in digital cameras themselves. As a result, miniaturization is eagerly sought also in taking lens systems, which occupy the largest volumes in digital input devices. The easiest way to make a taking lens system smaller is to make a solid-state image sensor smaller. However,

this involves making photosensitive elements smaller, and thus makes the solid-state image sensor more difficult to fabricate, and in addition requires higher performance in the taking lens system.

[0004]

5 On the other hand, making a taking lens system smaller while keeping the size of a solid-state image sensor unchanged inevitably brings the exit pupil position closer to the image plane. When the exit pupil position is brought closer to the image plane, the off-axial rays exiting from the taking lens system are obliquely incident on the image plane. This makes it impossible to make the most of the light-condensing ability of the microlenses

10 provided in front of the solid-state image sensor, with the result that the obtained image shows extremely uneven brightness between in a central portion and in a peripheral portion thereof. This can be avoided by bringing the exit pupil position of the taking lens system farther away from the image plane, but this inevitably makes the taking lens system as a whole unduly large.

[0005]

15 Furthermore, in keen competition for lower prices in recent years, lower costs have been increasingly eagerly sought in taking lens systems. To meet these requirements, Patent Publications 1 and 2 listed below propose taking lens systems composed of three lens elements for use with solid-state image sensors.

[0006]

20 [Patent Publication 1]

Japanese Patent Application (unexamined), published as JP 2002-517773

[Patent Publication 2]

Japanese Translation of PCT International Patent Application, published as No. JP 2002-98889

25 [0007]

[Problems to be Solved by the Invention]

However, the taking lens system proposed in Patent Publication 1 is composed solely of plastic lens elements, and thus has the disadvantage of a large deterioration in performance against variation in temperature. Moreover, this taking lens system has an angle of view of

30 about 50 degrees, which is insufficient for it to be used as a taking lens system. On the other hand, the taking lens system proposed in Patent Publication 2 is composed of two glass lens elements and one plastic lens element, but this construction, despite using two glass lens elements, has the disadvantage of a large deterioration in performance against variation in

temperature.   Moreover, the use of two glass lens elements results in high costs.

[0008]

An object of the present invention is to provide an inexpensive, compact taking lens system for use with a solid-state image sensor wherein glass and plastic lens elements are arranged appropriately to achieve satisfactory optical performance with little deterioration in performance against variation in temperature.

[0009]

[Means for Solving the Problem]

To achieve the above object, according to one aspect of the present invention, in a three-lens-element taking lens system for forming an image on a solid-state image sensor, comprising, from the object side, a first lens element having a positive optical power, an aperture stop, a second lens element having a positive optical power, and a third lens element having a negative optical power and having a concave surface pointing to the image side has the following features: of the first and second lens elements, one is a glass lens element and the other is a plastic lens element; the third lens element is a plastic lens element; and the following condition is fulfilled:

$$0.3 < f / fG < 2.6 \tag{1}$$

where

f   represents the focal length of the taking lens system as a whole; and

fG   represents the focal length of the glass lens element having a positive optical power.

[0010]

According to another aspect of the present invention, in a three-lens-element taking lens system for forming an image on a solid-state image sensor, comprising, from the object side, a first lens element having a positive optical power, an aperture stop, a second lens element having a positive optical power, and a third lens element having a negative optical power and having a concave surface pointing to the image side has the following features: of the first and second lens elements, one is a glass lens element and the other is a plastic lens element; the third lens element is a plastic lens element; and the following condition is fulfilled:

$$0.05 < TG / fG < 1.35 \tag{2}$$

where

TG   represents the axial thickness of the glass lens element having a positive optical

power; and

fG represents the focal length of the glass lens element having a positive optical power.

[0011]

According to another aspect of the present invention, in a three-lens-element taking lens system for forming an image on a solid-state image sensor, comprising, from the object side, a first lens element having a positive optical power, an aperture stop, a second lens element having a positive optical power, and a third lens element having a negative optical power and having a concave surface pointing to the image side has the following features: of the first and second lens elements, one is a glass lens element and the other is a plastic lens element; the third lens element is a plastic lens element; and the following condition is fulfilled:

$$| f3 | / fP < 2.6 \qquad\qquad (3)$$

where

f3 represents the focal length of the third lens element; and

fP represents the focal length of the plastic lens element having a positive optical power.

[0012]

According to another aspect of the present invention, in a three-lens-element taking lens system for forming an image on a solid-state image sensor, comprising, from the object side, a first lens element having a positive optical power, an aperture stop, a second lens element having a positive optical power, and a third lens element having a negative optical power and having a concave surface pointing to the image side has the following features: of the first and second lens elements, one is a glass lens element and the other is a plastic lens element; the third lens element is a plastic lens element; and the following condition is fulfilled:

$$0.05 < T3 / f < 0.5 \qquad\qquad (4)$$

where

T3 represents the axial thickness of the third lens element; and

f represents the focal length of the taking lens system as a whole.

[0013]

According to another aspect of the present invention, in a three-lens-element taking lens system for forming an image on a solid-state image sensor, comprising, from the object

side, a first lens element having a positive optical power, an aperture stop, a second lens element having a positive optical power, and a third lens element having a negative optical power and having a concave surface pointing to the image side has the following features: of the first and second lens elements, one is a glass lens element and the other is a plastic lens

5 element; the third lens element is a plastic lens element; and the following condition is fulfilled:

$$VG > 58 \tag{5}$$

where

VG   represents an Abbe number of the glass lens element having a positive optical

10   power.

[0014]

[Embodiment]

Hereinafter, taking lens systems embodying the present invention will be described with reference to the drawings. Figs. 1 to 3 show the lens construction, as seen in an optical

15 section, of the taking lens systems of a first to a third embodiment, respectively, of the invention. The taking lens systems of these embodiments are all single-focal-length lens systems designed for image taking purposes (for example, in a digital camera), i.e., for forming an optical image on a solid-state image sensor (for example, a CCD). In all these embodiments, the taking lens system has a three-lens-element construction composed of, from

20 the object side, a first lens element (L1) having a positive optical power, an aperture stop (ST), a second lens element (L2) having a positive optical power, and a third lens element (L3) having a negative optical power and having a concave surface pointing to the image side, and, at the image-side end of the taking lens system, there is disposed a glass filter (GF) having parallel flat surfaces and corresponding to an optical low-pass filter or the like. Moreover, in

25 all of the first to third embodiments, all the lens surfaces (r1, r2, and r4 to r7) are aspherical surface.

[0015]

Now, the lens construction of each embodiment will be described in more detail. In the first embodiment, the first lens element (L1) is a plastic positive meniscus lens element having a convex surface pointing to the image side, the second lens element (L2) is a glass

30 positive meniscus lens element having a convex surface pointing to the image side, and the third lens element (L3) is a plastic negative meniscus lens element having a concave surface pointing to the image side. In the second embodiment, the first lens element (L1) is a glass

positive meniscus lens element having a convex surface pointing to the object side, the second lens element (L2) is a plastic positive meniscus lens element having a convex surface pointing to the image side, and the third lens element (L3) is a plastic negative biconcave lens element. In the third embodiment, the first lens element (L1) is a glass positive meniscus lens element having a convex surface pointing to the object side, the second lens element (L2) is a plastic positive meniscus lens element having a convex surface pointing to the image side, and the third lens element (L3) is a plastic negative meniscus lens element having a concave surface pointing to the image side.

[0016]

In all of the first to third embodiments, the taking lens system has a positive-positive-negative optical power arrangement (an optical power is a quantity given as the reciprocal of a focal length), a glass lens element is used as one of the first and second lens elements (L1 and L2), a plastic lens element is used as the other, and a plastic lens element having a concave surface pointing to the image side is used as the third lens element (L3). This makes it possible to achieve a proper balance between the exit pupil position, optical performance, cost, compactness, and productivity required in a taking lens system for use with a solid-state image sensor. The conditions that should better be fulfilled to effectively achieve this will be described below.

[0017]

First, the conditional formulae that should preferably be fulfilled by the taking lens system of each embodiment, i.e., the conditional formulae of which the fulfillment is preferable in a taking lens system of the type like that of each embodiment, will be described. It is to be noted, however, that it is not necessary to fulfill all the conditional formulae described below simultaneously; that is, the fulfillment of whichever of those conditional formulae are appropriate in a given optical construction provides the corresponding benefits and advantages. Needless to say, it is preferable that as many of the conditional formulae as possible be fulfilled from the viewpoint of optical performance, miniaturization, production and assembly, and other factors.

[0018]

It is preferable that conditional formula (1) below be fulfilled.

$$0.3 < f / fG < 2.6 \qquad\qquad (1)$$

where

f   represents the focal length of the taking lens system as a whole; and

fG   represents the focal length of the glass lens element having a positive optical power.

[0019]

Conditional formula (1) defines the conditional range that should preferably be fulfilled by the positive glass lens element in the positive-positive-negative arrangement to achieve a proper balance between temperature-related variation in performance and the various aberrations produced.   Disregarding the lower limit of conditional formula (1) results in large temperature-related variation in performance.   By contrast, disregarding the upper limit of conditional formula (1), while helping reduce temperature-related variation in performance, leads to large distortion and coma.

[0020]

It is preferable that conditional formula (2) below be fulfilled.

$$0.05 < TG / fG < 1.35 \qquad\qquad (2)$$

where

TG   represents the axial thickness of the glass lens element having a positive optical power; and

fG   represents the focal length of the glass lens element having a positive optical power.

[0021]

Conditional formula (2) defines the conditional range that should preferably be fulfilled by the positive glass lens element in the positive-positive-negative arrangement to achieve a proper balance between temperature-related variation in performance and the conditions for the fabrication of the glass lens element.   Disregarding the upper limit of conditional formula (2) results in large temperature-related variation in performance.   By contrast, disregarding the lower limit of conditional formula (2), while helping reduce temperature-related variation in performance, results in making the glass lens element too thin. This makes it impossible to secure a sufficient thickness in a peripheral portion of the lens element, and thus makes it impossible to fabricate it.

[0022]

It is preferable that conditional formula (3) below be fulfilled.

$$| f3 | / fP < 2.6 \qquad\qquad (3)$$

where

f3   represents the focal length of the third lens element; and

fP   represents the focal length of the plastic lens element having a positive optical
        power.

[0023]

Conditional formula (3) defines the conditional range that should preferably be
fulfilled by the plastic lens elements, i.e., the lens elements other than the glass lens element,
to achieve a proper balance of temperature-related variation in performance.   Disregarding
conditional formula (3) results in large temperature-related variation in performance.

[0024]

It is preferable that conditional formula (4) below be fulfilled.

$$0.05 < T3 / f < 0.5 \qquad\qquad (4)$$

where

T3   represents the axial thickness of the third lens element; and

f   represents the focal length of the taking lens system as a whole.

[0025]

Conditional formula (4) defines the conditional range that should preferably be
fulfilled by the third lens element (L3), i.e., the only negative lens element in the positive-
positive-negative arrangement, to achieve a proper balance between temperature-related
variation in performance and the various aberrations produced.   Disregarding the upper limit
of conditional formula (4) results in large temperature-related variation in performance.   By
contrast, disregarding the lower limit of conditional formula (4), while helping reduce
temperature-related variation in performance, leads to large distortion and coma.

[0026]

It is preferable that conditional formula (5) below be fulfilled.

$$VG > 58 \qquad\qquad (5)$$

where

VG   represents the Abbe number of the glass lens element having a positive optical
        power.

[0027]

Conditional formula (5) defines the conditional range that should preferably be
fulfilled with respect to the correction of chromatic aberration by the glass lens element.
Disregarding conditional formula (5) causes the glass lens element to undercorrect chromatic
aberration, resulting in large chromatic aberration as a whole.   On the other hand, attempting
to fulfill conditional formula (5) by the use of a plastic lens element necessitates the use of an

extremely expensive material.

[0028]

As in any of the embodiments, it is preferable that all the lens elements each have an aspherical surface at least on one side thereof. Giving at least one aspherical surface to each of the first to third lens elements (L1 to L3) is highly effective in correcting spherical aberration, coma, and distortion. In all the embodiments, the taking lens system is composed solely of refractive lens elements, which deflect incident light by refraction (i.e. lens elements of the type that deflects light at the interface between two media having different refractive indices). It is possible, however, to replace any of these lens elements with a lens element of any other type, for example, a diffractive lens element, which deflects incident light by diffraction, or a refractive/diffractive hybrid lens element, which deflects incident light by diffraction and refraction combined together, or a gradient index lens element, which deflects incident light with varying refractive indices distributed within a medium. Among these types, gradient index lens elements, which have varying refractive indices distributed within a medium, are expensive because of the complicated fabrication process they require. Therefore, in a taking lens system embodying the invention, it is preferable to use lens elements formed of a uniform material as all of the lens elements (L1 to L3).

[0029]

In any of the embodiments, a surface having no optical power (for example, a reflective, refractive, or diffractive surface) may be arranged in the optical path so as to bend the optical path in front of, behind, or in the middle of the taking lens system. Where to bend the optical path may be determined to suit particular needs. By bending the optical path appropriately, it is possible to make apparently slim and compact the digital input apparatus (such as a digital camera) in which the taking lens system is incorporated. As required, in addition to the aperture stop (ST), a beam restricting plate or the like for cutting unnecessary light may be arranged.

[0030]

The taking lens systems of the first to third embodiments are all suitable as compact taking lens systems for use in digital input apparatuses, and, by combining one of those taking lens systems with an optical low-pass filter and a solid-state image sensor, it is possible to build a taking lens apparatus that takes in an image of a subject optically and outputs it as an electrical signal. A taking lens apparatus is used as the main component of a camera that is used to take a still or moving picture of a subject (for example, digital cameras; video

cameras; and cameras incorporated in or externally fitted to digital video units, personal computers, mobile computers, pen-type scanners, cellular phones, and personal digital assistants (PDAs)). A taking lens apparatus is composed of, for example, from the object (subject) side, a taking lens system for forming an optical image of a subject, an optical low-pass filter, and a solid-state image sensor for converting the optical image formed by the taking lens system into an electrical signal.

[0031]

Thus, the embodiments described hereinbefore include constructions (i) to (iv) as noted below, and, with those constructions, it is possible to realize high-optical-performance, low-cost, compact taking lens apparatuses. By incorporating such a taking lens apparatus in a digital camera or the like, it is possible to enhance the performance and functionality of the camera, and to reduce the costs and size thereof.

(i) A taking lens apparatus comprising a taking lens system for forming an optical image and a solid-state image sensor for converting the optical image formed by the taking lens system into an electrical signal, the taking lens system comprising, from the object side, a first lens element having a positive optical power, an aperture stop, a second lens element having a positive optical power, and a third lens element having a negative optical power and having a concave surface pointing to the image side, wherein, of the first and second lens elements, one is a glass lens element and the other is a plastic lens element, wherein the third lens element is a plastic lens element, and wherein at least one of conditional formulae (1) to (5) is fulfilled.

(ii) A taking lens apparatus comprising a taking lens system for forming an optical image and a solid-state image sensor for converting the optical image formed by the taking lens system into an electrical signal, the taking lens system comprising, from the object side, a first lens element having a positive optical power, an aperture stop, a second lens element having a positive optical power, and a third lens element having a negative optical power, wherein, of the first and second lens elements, one is a glass meniscus lens element and the other is a plastic meniscus lens element, wherein the third lens element is a plastic meniscus lens element having a concave surface pointing to the image side or a plastic biconcave lens element, and wherein at least one of conditional formulae (1) to (5) is fulfilled.

(iii) A taking lens apparatus as described in (i) or (ii) above, wherein all the lens elements each have at least one aspherical surface.

(iv) A taking lens apparatus as described in one of (i) to (iii) above, wherein all the

lens elements are each formed out of a uniform material.

[0032]

Used as the solid-state image sensor is, for example, a CCD or CMOS (complementary metal oxide semiconductor) sensor having a plurality of pixels. The optical image formed by the taking lens system is converted into an electrical signal by the solid-state image sensor. The optical image to be formed by the taking lens system passes through the optical low-pass filter having a predetermined cutoff frequency characteristic that depends on the pixel pitch of the solid-state image sensor, and meanwhile the optical image has its spatial frequency characteristic so adjusted as to minimize so-called aliasing noise generated when the optical image is converted into an electric signal. The signal produced by the solid-state image sensor is subjected to predetermined digital image processing, image compression processing, and the like as required, and is recorded in a memory (such as a semiconductor memory or an optical disk) as a digital video signal; in some cases, the signal is transferred to another apparatus through a cable or after being converted into an infrared signal.

[0033]

In the embodiments, a glass filter GF is used as the optical low-pass filter disposed between the last surface of the taking lens system and the solid-state image sensor. It is possible, however, to use instead an optical low-pass filter of any other type that suits the digital input apparatus in which the taking lens system is incorporated. For example, it is possible to use a birefringence-type low-pass filter made of quartz or the like having an appropriately aligned crystal axis, a phase-type low-pass filter that achieves the required optical cut-off frequency characteristics by exploiting diffraction, or a low-pass filter of any other type.

[0034]

[Examples]

Hereinafter, practical examples of taking lens systems embodying the present invention will be presented with reference to their construction data and other data. Examples 1 to 3 presented below correspond to the first to third embodiments described hereinbefore. Thus, the lens construction diagrams (Figs. 1 to 3) of the first to third embodiments also show the lens constructions of Examples 1 to 3, respectively. In the construction data of each example, r_i ($i = 1, 2, 3, \ldots$) represents the radius of curvature (mm) of the i-th surface from the object side, d_i ($i = 1, 2, 3, \ldots$) represents the i-th axial distance (mm) from the object side, and N_i ($i = 1, 2, 3,$ and 4) and v_i ($i = 1, 2, 3,$ and 4) respectively

represent the refractive index (Nd) for the d-line and the Abbe number (vd) of the i-th optical element from the object side. Shown together with these data are the focal length (f, mm) and the f-number (FNO) of the taking lens system as a whole. Table 1 shows the values of the conditional formulae as actually observed in Examples 1 to 3.

[0035]

A surface of which the radius of curvature ri is marked with an asterisk (*) is a refractive optical surface having an aspherical shape or a surface that exerts a refractive effect equivalent to that of an aspherical surface. The surface shape of such an aspherical surface is defined by formula (AS) below. The aspherical surface data of the aspherical surfaces used in each example are also shown together with the other data mentioned above.

$$X(H) = \left(C0 \cdot H^2\right)\Big/\left(1 + \sqrt{1 - \varepsilon \cdot C0^2 \cdot H^2}\right) + \sum\left(Ai \cdot H^i\right) \quad \text{(AS)}$$

where

X(H)   represents the displacement along the optical axis AX at the height H (relative to the vertex);

H   represents the height in a direction perpendicular to the optical axis AX;

C0   represents the paraxial curvature (= the reciprocal of the radius of curvature);

ε   represents the quadric surface parameter; and

Ai   represents the aspherical surface coefficient of i-th order (the data are omitted if Ai = 0).

[0036]

Figs. 4 to 6 show aberration diagrams of Examples 1 to 3, respectively. Of these aberration diagrams, those indicated as "A" show spherical aberration, those indicated as "B" show astigmatism, and those indicated as "C" show distortion (with FNO representing the f-number and Y' representing the maximum image height (mm)). In the diagrams showing spherical aberration, the solid line (d), dash-and-dot line (g), and dash-dot-dot line (c) represent the spherical aberration (mm) observed for the d-, g-, and c-lines, respectively, and the broken line (SC) represents the deviation (mm) from the sine condition. In the diagrams showing astigmatism, the broken line (DM) and the solid line (DS) represent the astigmatism (mm) observed for the d-line on the meridional and sagittal planes, respectively. In the diagrams showing distortion, the solid line represents the distortion (%) observed for the d-line.

[0037]

<< Example 1 >>
f=3.382, FNO=2.80

	Radius of Curvature	Axial Distance	Refractive Index	Abbe Number
r1*=	−10.748			
		d1= 0.756	N1=1.53048	ν1= 55.72(L1)
r2*=	−6.165			
		d2= 0.933		
r3=	∞(ST)			
		d3= 0.500		
r4*=	−12.672			
		d4= 1.734	N2=1.48749	ν2= 70.44(L2)
r5*=	−0.898			
		d5= 0.100		
r6*=	5.623			
		d6= 0.700	N3=1.58340	ν3= 30.23(L3)
r7*=	1.145			
		d7= 1.300		
r8=	∞			
		d8= 0.500	N4=1.51680	ν4= 64.20(GF)
r9=	∞			

[0038]

[Aspherical Surface Data of Surface r1]
$\varepsilon=-0.49000\times10^{2}$, A4= 0.19628×10^{-1}, A6= 0.42261×10^{-2}, A8=-0.14046×10^{-2},
A10= 0.24571×10^{-3}

[Aspherical Surface Data of Surface r2]
$\varepsilon=-0.61499\times10$, A4= 0.46300×10^{-1}, A6= 0.58156×10^{-2}, A8=-0.55287×10^{-2},
A10= 0.25143×10^{-2}

[Aspherical Surface Data of Surface r4]
$\varepsilon=-0.10000\times10$, A4=$-0.36178\times10^{-1}$, A6=$-0.35359\times10^{-1}$, A8= 0.33661×10^{-1},
A10=-0.76906×10^{-1}

[Aspherical Surface Data of Surface r5]
$\varepsilon=-0.10000\times10$, A4= 0.88131×10^{-2}, A6=-0.10394, A8= 0.66365×10^{-1},
A10=-0.21004×10^{-1}

[Aspherical Surface Data of Surface r6]
$\varepsilon=-0.19193\times10$, A4=$-0.51842\times10^{-1}$, A6= 0.75512×10^{-3}, A8= 0.23514×10^{-2},
A10=-0.21619×10^{-2}

[Aspherical Surface Data of Surface r7]
$\varepsilon=-0.45157\times10$, A4=$-0.44404\times10^{-1}$, A6= 0.19663×10^{-1}, A8=-0.73281×10^{-2},
A10= 0.92529×10^{-3}

[0039]

<< Example 2 >>

f=5.403, FNO=2.80

	Radius of Curvature	Axial Distance	Refractive Index	Abbe Number
r1*=	3.427			
		d1= 1.256	N1=1.58913	v1= 61.28(L1)
r2*=	13.824			
		d2= 0.643		
r3=	∞(ST)			
		d3= 0.972		
r4*=	−3.551			
		d4= 1.640	N2=1.53048	v2= 55.72(L2)
r5*=	−1.328			
		d5= 0.100		
r6*=	−31.222			
		d6= 1.584	N3=1.58340	v3= 30.23(L3)
r7*=	2.125			
		d7= 0.800		
r8=	∞			
		d8= 0.500	N4=1.51680	v4= 64.20(GF)
r9=	∞			

[0040]

[Aspherical Surface Data of Surface r1]
ε= 0.45664, A4= 0.50687×10^{-2}, A6= 0.84990×10^{-3}, A8=-0.13419×10^{-4}, A10= 0.45261×10^{-4}

[Aspherical Surface Data of Surface r2]
ε= 0.13638×10^{2}, A4= 0.12538×10^{-1}, A6=-0.40314×10^{-2}, A8= 0.29052×10^{-2}, A10=-0.63264×10^{-3}

[Aspherical Surface Data of Surface r4]
ε= 0.20000×10, A4=-0.17811×10^{-1}, A6=-0.44803×10^{-1}, A8= 0.25403×10^{-1}, A10=-0.27515×10^{-2}

[Aspherical Surface Data of Surface r5]
ε= 0.28496, A4=-0.90398×10^{-3}, A6= 0.58812×10^{-2}, A8=-0.40268×10^{-2}, A10= 0.10098×10^{-2}

[Aspherical Surface Data of Surface r6]
ε= 0.0, A4=-0.60414×10^{-1}, A6= 0.15910×10^{-1}, A8=-0.10850×10^{-2}, A10=-0.90198×10^{-4}

[Aspherical Surface Data of Surface r7]
ε=-0.52095×10, A4=-0.30068×10^{-1}, A6= 0.30856×10^{-2}, A8=-0.17047×10^{-3}, A10= 0.10885×10^{-6}

[0041]

<< Example 3 >>
f=4.212, FNO=4.00

	Radius of Curvature	Axial Distance	Refractive Index	Abbe Number
5	r1*= 1.823			
		d1= 1.195	N1=1.48749	ν1= 70.44(L1)
	r2*= 17.003			
		d2= 0.300		
	r3= ∞(ST)			
10		d3= 0.575		
	r4*= −1.231			
		d4= 1.371	N2=1.53048	ν2= 55.72(L2)
	r5*= −0.881			
		d5= 0.100		
15	r6*= 4.980			
		d6= 0.749	N3=1.58340	ν3= 30.23(L3)
	r7*= 1.193			
		d7= 0.500		
	r8= ∞			
20		d8= 0.500	N4=1.51680	ν4= 64.20(GF)
	r9= ∞			

[0042]

[Aspherical Surface Data of Surface r1]
$\varepsilon= 0.41144$, $A4= 0.85264\times10^{-2}$, $A6= 0.61779\times10^{-2}$, $A8=-0.18563\times10^{-2}$,
25 $A10=-0.12302\times10^{-2}$

[Aspherical Surface Data of Surface r2]
$\varepsilon= 0.16000\times10^{2}$, $A4=-0.94292\times10^{-2}$, $A6=-0.39468\times10^{-1}$, $A8= 0.43553\times10^{-1}$,
$A10=-0.19370\times10^{-1}$
30

[Aspherical Surface Data of Surface r4]
$\varepsilon= 0.19571\times10$, $A4=-0.22360\times10^{-1}$, $A6=-0.23890$, $A8= 0.29336$,
$A10= 0.36819$

35 [Aspherical Surface Data of Surface r5]
$\varepsilon= 0.66179\times10^{-1}$, $A4= 0.59525\times10^{-1}$, $A6=-0.70445\times10^{-1}$, $A8= 0.15571\times10^{-1}$,
$A10= 0.54156\times10^{-2}$

[Aspherical Surface Data of Surface r6]
40 $\varepsilon= 0.12482\times10$, $A4=-0.14933$, $A6= 0.56598\times10^{-1}$, $A8=-0.76101\times10^{-2}$,
$A10=-0.24802\times10^{-4}$

[Aspherical Surface Data of Surface r7]
$\varepsilon=-0.60000\times10$, $A4=-0.74292\times10^{-1}$, $A6= 0.64193\times10^{-2}$, $A8= 0.15186\times10^{-2}$,
45 $A10=-0.29432\times10^{-3}$

[0043]

[Table 1]

	Conditional Formula (1)	Conditional Formula (2)	Conditional Formula (3)	Conditional Formula (4)	Conditional Formula (5)
	f / fG	TG / fG	| f3 | / fP	T3 / f	VG
Example 1	1.79	0.92	0.10	0.21	70.44
Example 2	0.73	0.17	1.05	0.29	61.28
Example 3	1.03	0.29	1.17	0.18	70.44

[0044]

[Advantages of the Invention]

As described above, according to the present invention, it is possible to realize an inexpensive, compact taking lens system for use with a solid-state image sensor which offers satisfactory optical performance in combination with little deterioration in performance against variation in temperature. By incorporating a taking lens system according to the invention in a digital input apparatus such as a camera incorporated in a cellular phone or a digital camera, it is possible to enhance the performance and functionality of the apparatus, and to reduce the costs and size thereof.

[Brief Description of the Drawings]

[Fig. 1]

A lens construction diagram of a first embodiment (Example 1) of the invention.

[Fig. 2]

A lens construction diagram of a second embodiment (Example 2) of the invention.

[Fig. 3]

A lens construction diagram of a third embodiment (Example 3) of the invention.

[Fig. 4]

Aberration diagrams of Example 1.

[Fig. 5]

Aberration diagrams of Example 2.

[Fig. 6]

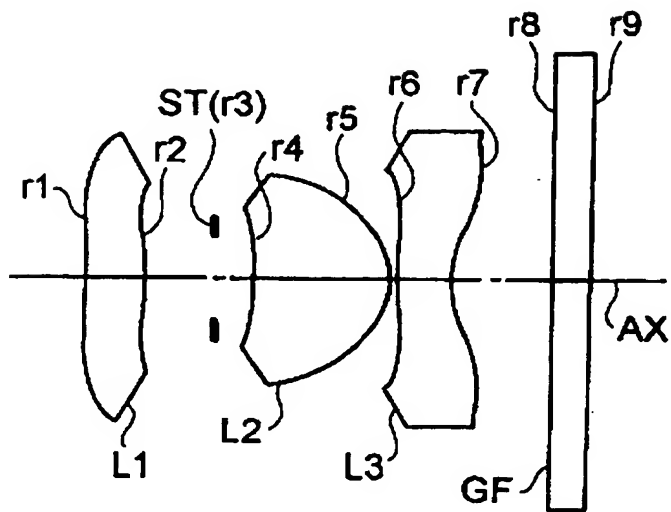Aberration diagrams of Example 3.

[Description of the Reference Designations]
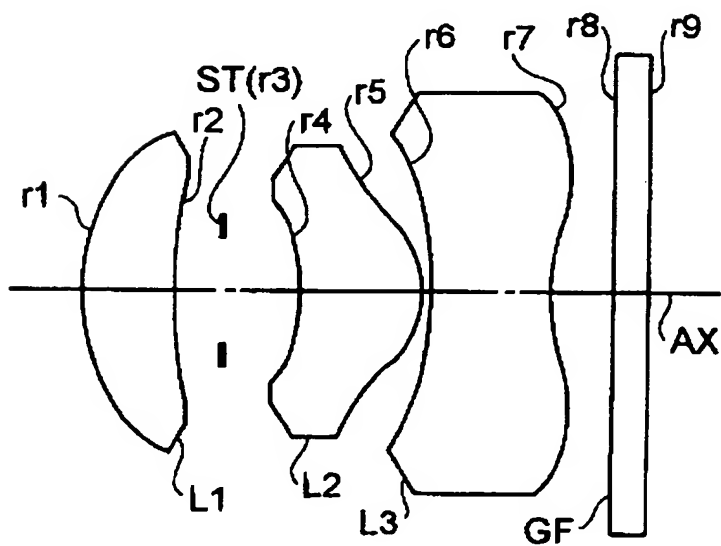
L1   First Lens Element

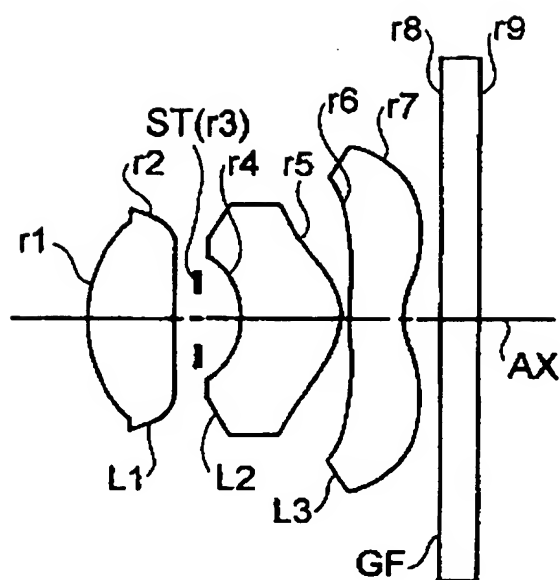|	ST	Aperture Stop
	L2	Second Lens Element
	L3	Third Lens Element
	GF	Glass Filter
5	AX	Optical Axis

[Title of the Document]   Drawings

[Fig. 1]

[Fig. 2]

[Fig. 3]

[Fig. 4]

(A)
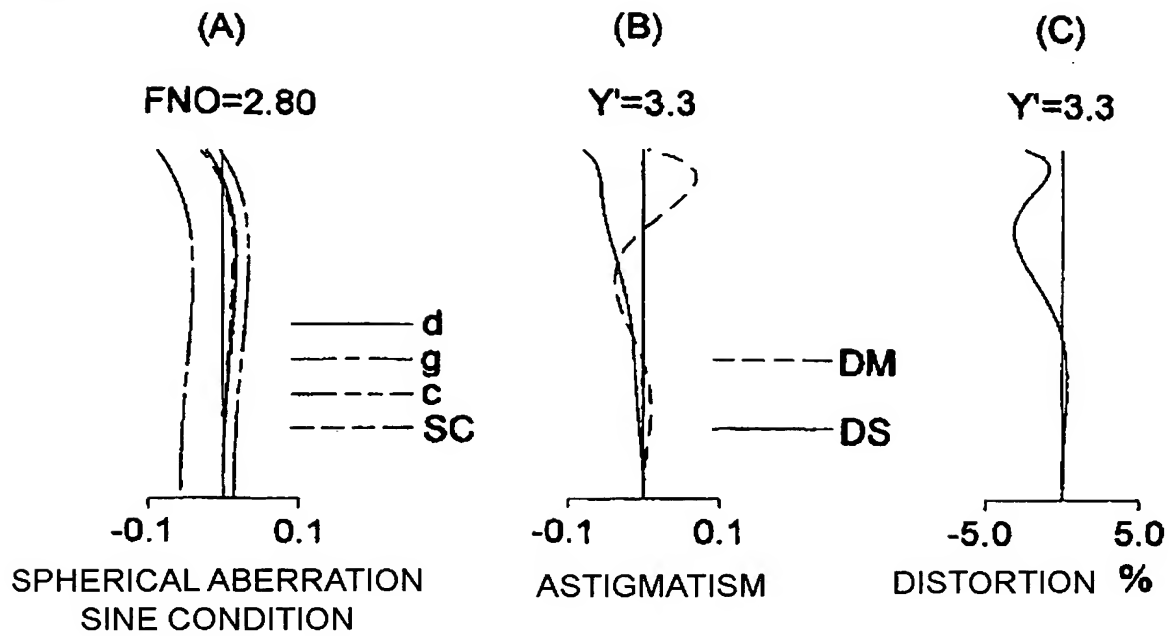FNO=2.80

(B)
Y'=2.3

(C)
Y'=2.3

——	d
———	g
––––	c
–––	SC

–––	DM
——	DS

-0.1   0.1
SPHERICAL ABERRATION
SINE CONDITION

-0.1   0.1
ASTIGMATISM

-5.0   5.0
DISTORTION %

2

[Fig. 5]

(A)	(B)	(C)
FNO=2.80	Y'=3.3	Y'=3.3

d
g
c
SC

DM

DS

-0.1   0.1

SPHERICAL ABERRATION
SINE CONDITION

-0.1   0.1

ASTIGMATISM

-5.0   5.0

DISTORTION %

[Fig. 6]

(A)	(B)	(C)
FNO=4.00	Y'=2.5	Y'=2.5

d
g
c
SC

DM

DS

-0.1   0.1

SPHERICAL ABERRATION
SINE CONDITION

-0.1   0.1

ASTIGMATISM

-5.0   5.0

DISTORTION %
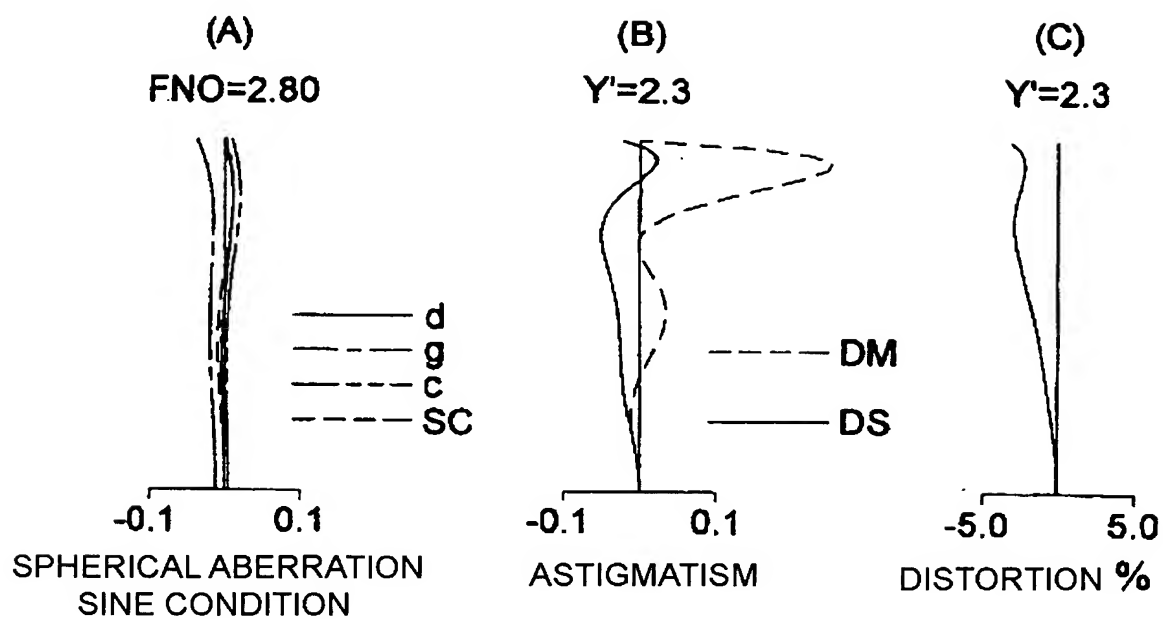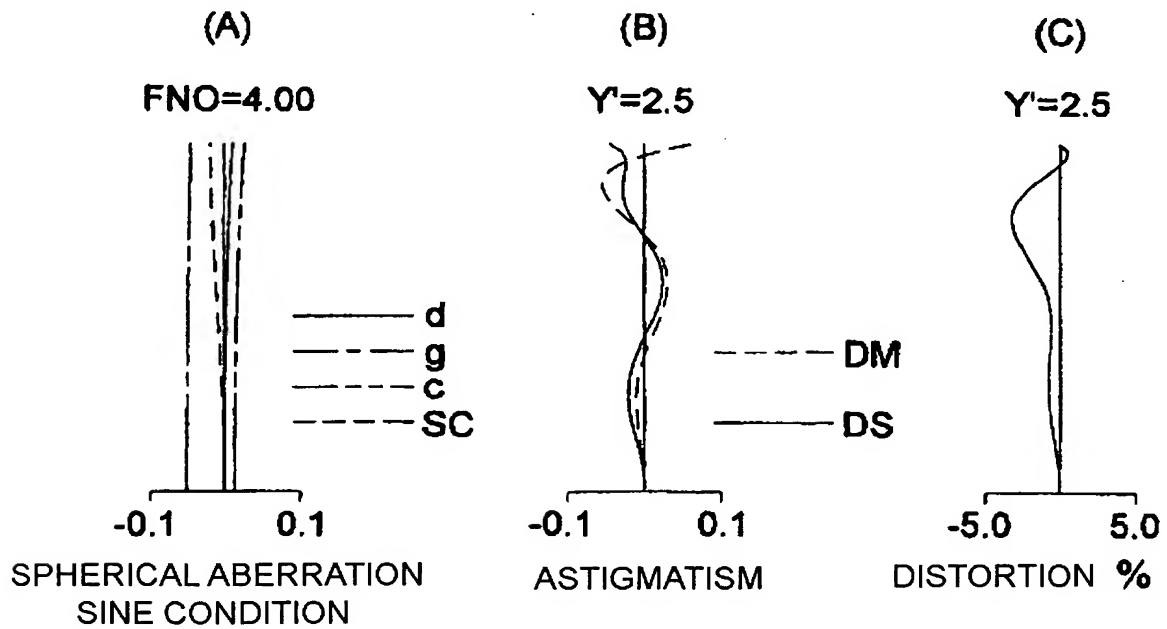
[Title of the Document]   Abstract

[Abstract]

[Object]   To provide an inexpensive, compact taking lens system for use with a solid-state image sensor wherein glass and plastic lens elements are arranged appropriately to achieve satisfactory optical performance with little deterioration in performance against variation in temperature

[Features]   A three-lens-element taking lens system for forming an image on a solid-state image sensor has, from the object side, a first lens element (L1) having a positive optical power, an aperture stop (ST), a second lens element (L2) having a positive optical power, and a third lens element (L3) having a negative optical power and having a concave surface pointing to the image side.   Of the first and second lens elements (L1 and L2), one is a glass lens element and the other is a plastic lens element.   The third lens element (L3) is a plastic lens element.   The following condition is fulfilled: $0.3 < f / fG < 2.6$ (where f represents the focal length of the taking lens system as a whole, and fG represents the focal length of the glass lens element having a positive optical power).

[Selected Figure]   Fig. 1

INFORMATION ON APPLICANT'S HISTORY

Identification Number   [000006079]

1.   Date of Correction   August 27, 1990

      [Grounds for Correction]   New Registration

            Address: Osaka Kokusai Bldg., 3-13,
                             2-Chome, Azuchi-Machi, Chuo-ku,
                             Osaka-Shi, Osaka-Fu

            Name: Minolta Camera Co., Ltd.

2.   Date of Correction   July 20, 1994

      [Grounds for Correction]   Change in Corporation Name

            Address: Osaka Kokusai Bldg., 3-13,
                             2-Chome, Azuchi-Machi, Chuo-ku,
                             Osaka-Shi, Osaka-Fu

            Name: Minolta Co., Ltd.